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Contrasted the clinical and radiological results of patients receiving cage-based bone grafting with PLIF surgical treatment that included bone grafting

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ABSTRACT

Aims: Posterior lumbar interbody fusion (PLIF) is frequently used to treat spinal instabilities that can cause neurological symptoms, leg pain and low back pain including lumbar stenosis, degenerative disc disease and spondylolisthesis in which one vertebra slips over another. This study aimed to compare the clinical and radiographic outcomes of PLIF for degenerative L4 unstable grade III spondylolisthesis using bone grafts and cage bone grafts.

Methods: Between from September 2021 to August 2023, 30 patients with degenerative lumbar spine disorders were selected based on the inclusion and exclusion criteria for PLIF.

Results: We enrolled 30 patients and divided them into 2 groups (bone graft group I and cage bone graft group II). The follow-up period was 2 years. Low back pain and leg function of the Japanese Orthopaedic Association score showed significant improvement ($p<0.005$) at 3 months and at the final postoperative (62.1±5.5, 602±5.1) in both groups. The fusion rate was 93% in group I and 83% in group II. Radiological evaluation showed significant changes in slip angle, disc height, lumbar lordosis and translational motion from preoperative to final follow-up in both groups. A computer tomography revealed bilateral spondylolysis, disc collapse and anterolisthesis of the fifth lumbar vertebra. These results were verified by magnetic resonance imaging. There was no spinal canal stenosis.

Conclusion: These findings suggest that successful clinical and radiological results can be obtained with PLIF surgery using either a cage with bone or a bone graft alone. The surgeon's inclination, the particular state of the patient and the resources at hand may influence which of the two approaches is used. The results showed no statistically significant difference between the two groups in terms of clinical and radiological outcomes (bone graft and cage with bone graft). This indicates that neither strategy showed a clear edge over the others in the criteria under study and both were equally successful in yielding favorable outcomes.

Keywords: Spine surgery, lumbar disc surgery, interbody fusion, low back pain, spinal cord

INTRODUCTION

Traditionally surgical treatment known as posterior lumbar interbody fusion (PLIF) has been recommended for a variety of lumbar spinal pathologies, especially in individuals with degenerative lumbar spine problems. Various changes in the PLIF procedure have reportedly improved surgical comfort and arthrodesis rates. Compared to other posterolateral procedures, these circumferential fusion techniques offer clear theoretical advantages.[1,2] Direct access to the intervertebral disc is provided by the PLIF technique, allowing for complete removal of the injured or degenerative disc and careful endplate preparation for fusion.[3] As a result, the likelihood of obtaining solid fusion may increase. PLIF allows for simultaneous decompression of neural elements (such as nerve roots) and stabilization of the spine through fusion. This can effectively relieve pressure on the nerves while ensuring spinal stability.[4,5]

The likelihood of vertebral collapse was reduced and the compressive forces were dispersed more evenly. By filling the intervertebral disc space, the interbody graft stabilizes the motion segment and is frequently made of bone replacement. This helps prevent unwanted motion which can cause discomfort and instability by reducing mobility between

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nearby vertebra.[6] In spinal fusion treatments, interbody graft implantation is primarily performed to encourage bone fusion (arthrodesis) between the neighboring vertebra. This fusion stabilized the treated segment structurally and eliminated mobility. The development of less invasive PLIF methods has allowed surgeons to achieve good fusion rates while minimizing tissue damage, postoperative pain and recovery duration.[7]

Traditional spinal fusion procedures include PLIF with an iliac bone transplant but these procedures are associated with a number of risks and difficulties including morbidity related to the donor location and the patient's own iliac crest which is one of the most important problems with using an iliac bone graft for PLIF.[8] Removal of bone from the iliac crest can be extremely painful and uncomfortable which increases the risk of complications such as infection, hemorrhage and nerve damage.[9,10]

The surgical technique takes longer when an iliac crest bone graft is harvested because it requires a different surgical location and precise care during bone extraction. Surgery that lasts longer increases the risk of complications. The iliac crest had a finite supply of bone that could be removed.[11-13] The intervertebral gap may not be completely filled with graft material. Iliac bone grafts may undergo resorption over time. This may lead to less stability and adverse effects on the final outcome of fusion. There is a chance that the nerves and blood arteries in the area will be damaged during the graft-harvesting process which could result in numbness, weakness or vascular problems.[14] Infection is more likely to occur at both the donor and surgical sites in the lumbar spine because of the formation of a second surgical site (the iliac crest). Both the donor and surgical sites are frequently quite painful for patients which can lengthen recovery durations and lower patient satisfaction.[15]

In Turkiye, degenerative lumbar spine disorders are often multifactorial and different individuals may have varying combinations of these risk factors. Lifestyle modifications, regular exercise, maintaining a healthy weight and seeking appropriate medical care are essential for preventing or managing these disorders. Due to these potential problems associated with PLIF using an iliac bone graft alternative methods and graft materials have been developed and refined over the years. The aim of this study to compare the clinical and radiographic outcomes of PLIF for degenerative L4 unstable grade III spondylolisthesis.

METHODS

Study Design and Patients Data Collection

The study was initiated upon receiving approval from the Hitit University Faculty of Medicine Researches Ethics Committee (Date: 05.08.2021, Decision No: 2021-19). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Patients were prospectively recruited from September 2021 to August 2023 in the Department of Neurosurgery Hitit University Çorum Erol Olçok Training and Research Hospital. The patient population included patients aged 25-60 years. A total number of patients was 30. The patients were divided into two groups. Group A included 15 patients who underwent PLIF of the cage with bone transplant and group B included 15 patients who underwent PLIF with bone grafting. The following problems were present in patients who had a single vertebral level (L4) grade III decompression for unstable degenerative spondylolisthesis and were monitored for 24 months. The Japanese Orthopaedic Association (JOA) score is a thorough evaluation tool for individuals with spinal disorders particularly in the lumbar region. Radiographic imaging was used to assess clinical results. All participants provided written informed consent and the research was authorized by the Hitit University Faculty of Medicine Research Ethical Council. This study was conducted in conformity with the Declaration of Helsinki which is the World Medical Association's Code of Ethics for Human Subject Studies.

Inclusion criteria: Patients who underwent lumbar stability and fusion due to a degenerative lumbar spine condition were admitted to the neurosurgery department.

Exclusion criteria: Patients who are under 18 years old, older than 70 years, have active infections, are pregnant or have cancer.

Surgical Methods

Another form of spinal surgery PLIF is used to treat various lumbar spine disorders. In this step, any bone or tissue that might obstruct the spinal nerves in the lumbar region was removed. Decompression is required to relieve symptoms caused by disorders such as spinal stenosis, ruptured discs or other problems involving nerve compression. The transverse processes of the vertebra were separated using bone graft material. This bone graft material promoted vertebral fusion resulting in a stable spinal segment. An intervertebral disc or disc material is removed during PLIF treatment and replaced with either a bone graft or a spacer device. It is typically positioned in the intervertebral space between the two nearby vertebra. This interbody fusion can help further stabilize the spine by encouraging fusion between the vertebral bodies. The main objectives of PLIF are to decompress the spine, stabilize the injured area using pedicle screws, promote bone fusion and manage intervertebral disc problems. PLIF is frequently used to address spinal instability, disc herniation and degenerative disc degeneration. The cage was chosen based on the surgeon's preference.

Outcome Measurements

Clinical evaluation: Evaluation of a patient's condition both before and after surgery was performed using the JOA score and its subscores. These results are frequently used to assess the condition of people with spinal illnesses, particularly in relation to lumbar problems. It considers a patient's symptoms, functional restrictions and neurological abnormalities among other elements of their illness. The JOA score is an overall numerical number that represents the patient's state and is derived from responses to a series of questions or assessments. While a lower score typically denotes more severe symptoms and impairments a higher score typically denotes greater spinal function and less disability. To monitor the patient's development and success of the surgical intervention, these scores are routinely assessed at various intervals. To establish a baseline assessment of the patient's state, preoperative measurements were performed prior to surgery.

Radiological evaluation: Preoperatively, postoperatively and at the final follow-up, slide length and angle, slip ratio, disc height and lumbar lordosis were evaluated. By performing radiography on maximum flexion and extension at the time of the procedure the slip angle were calculated 3 months, 6 months and 1 year after the procedure. Radiography of the lumbosacral spine should be performed to determine the degree of instability, disc height and degree of lumbar lordosis. Examination of the disc height and pars interarticularis using a lumbar computer tomography (CT) scan. Neurological tissue assessment using magnetic resonance imaging (MRI) of the lumbar spine.

Statistical Analysis

To compare clinical and radiologic measures, T-tests were performed. The intertransverse fusion rates were compared using Fisher's exact test. The SPSS version 26 was used for all analyses. When the p value was less than 0.05 statistical significance was taken into account.

RESULTS

As shown in Table 1; the age and sex distributions in the two treatment groups for PLIF (bone graft and cage with bone graft) were comparable. The following conditions were present in the fourth lumbar vertebra and monitored for two years. A posterior opening of 5 mm in maximal flexion, a slip of 8° and Meyerding grade III or above were all required. There were 30 patients in all including both male and female patients and their ages ranged from 64.5±5.2 65.1±6.6 years. Both groups underwent follow-up period (2.1±0.3, 2.2±0.5).

Table 1. Demographic parameters of patients

Parameters	Group-I bone graft (n=15)	Group-II cage with bone graft (n=15)	p value
Age	64.5±5.2	65.1±6.6	0.87
Both sex	77.5	76.0	0.76
Weight	60.1±10.3	60.3±9.1	0.41
No of days in the hospital	30.5±5.5	29.9±1.3	0.21
Operating time	185.2±9.1	185.3±8.8	0.87
Fusion			
Yes	14=93%	13=87%	0.005
No	1=7%	2=13.3%	
Follow up period (Y)	2.1±0.3	2.2±0.5	0.33

Comparison of Clinical Outcomes from Preoperative to Postoperative between Two Groups

The clinical outcomes were evaluated using radiographic imaging. JOA scores were compared between the bone graft (group I) and cage with bone graft (group II) groups. There was a statistically significant decrease and improvement ($p<0.005$) in low back pain and leg pain (preoperative, 1 month, 3 months, 6 months, 1 year and follow-up) in both groups by analyzing the JOA scale. In group I, low back pain JOA score was significantly increased ($p<0.005$) at 3 months (43.2±11.7), 6 months (55.1±3.6), 1 year (59.1±6.1) and at final follow-up (62.1±5.5) postoperatively as compared to preoperatively (9.3±15.3). In group II, low back pain JOA score was significantly increased after treatment ($p<0.005$), after 3 months (40±21.4), 6 months (53.3±20.1), 1 year (60.2±3.3) and at final follow-up (62.5±5.1) postoperatively as compared to preoperatively (9.3±3.4). In group I, leg function improvement rates, from preoperative to 3 months, 6 months, 1 year and at final follow-up were (35.1±13.1), (40±19.2), (49.5±20.5) and (52.2±20.1) as compared to preoperatively (13.4±5.3); those patients belong to group II were (36.6±12.2), (49±22.6), (47±17.3) and (50.4±20.7) respectively then preoperative (12.5±4.1) in (Table 2, Figure 1).

Table 2. Comparison of LBP and leg function JOA scale between two groups

Parameters	LBP score (n=15) mean±SD		Leg score (n=15) mean±SD		p value
	Group-I	Group-II	Group-I	Group-II	
Preoperative	9.3±15.3	9.3±18.4	13.4±5.5	12.5±4.1	0.003
1 month	18.1±13.2	12.3±23.1	21.1±3.3	21.5±10.1	0.67
3 month	43.2±11.7	40±21.4	35.1±13.1	36.6±12.2	0.05
6 month	55.1±3.6	53.3±20.1	40±19.2	49±22.6	0.05
1 year	59.1±6.1	60.2±3.3	49.5±20.5	47±17.3	0.003
F/U	62.1±5.5	62±5.1	52.2±20.1	50.4±20.7	0.003

LBP: Low back pain, JOA: Japanese Orthopaedic Association, SD: Standard deviation

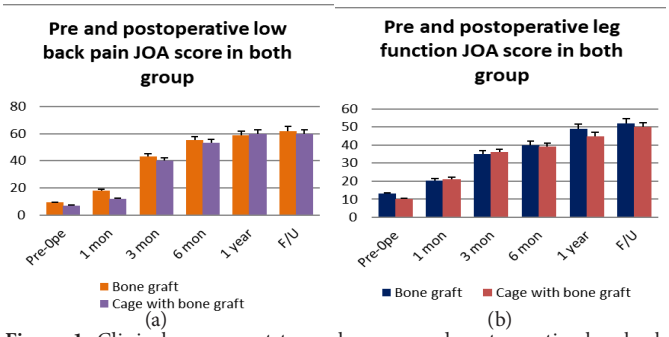


Figure 1. Clinical assessment to analyze pre and postoperative low back pain and leg function, (a) Bar graph shows significantly reduced low back pain by increasing JOA score, (b) Bar graph shows significantly reduced leg pain by increasing JOA score

JOA: Japanese Orthopaedic Association

Comparison of Radiographic Results from Preoperative to Postoperative between Two Groups

In bone graft group I and cage with bone graft in group II, the slip angle were decrease significantly, $p<0.05$, preoperatively, postoperatively and at the final follow-up. In group I, the slip angle increased (12.5°±0.5°) preoperatively and decrease at 6th month (6.0°±1.2°) postoperatively to (2.1°±2.1°) at the final follow-up. In group II, it increased (11.9°±1.1°) preoperatively and decreased at 6 months (6.1°±0.7°) postoperatively and (2.5°±0.9°) at the final follow-up (2.5°±0.9°) in (Table 3). At postoperative follow-up there was a significant ($p<0.05$) better correction from this time point through the final follow-up. In our study, significantly increased ($p<0.005$); disc height in bone graft group I and cage with bone graft in group II preoperatively, postoperatively and at follow-up. In group I, significantly increased preoperatively (20%±9%), at 6 months (55%±22%) postoperatively and at the final follow-up (60%±28%). In group II, preoperative vertebral disc heights were significantly decreased (19%±10%), 6 months (58%±23%) and (60%±25%) respectively. At the postoperative and final follow-up, the disc heights were 60% ($p<0.05$). There were no significant differences between the two groups (Table 3). In lumbar lordosis was significantly increased ($p < 0.005$) in group I and cage with bone graft in group II preoperatively, postoperatively and at follow-up. In group I, preoperative lumbar lordosis L4-S1 were (10.2°±3°), at 6 months (43°±19°) and at the final follow-up (60°±29°) ($p>0.005$). In group II, preoperative lumbar lordosis was 9%±2% and at 6 months (37%±16%) at the final follow-up (58%±21%) ($p>0.005$) in (Table 3), (Figure 2a, b, c). From that time point, translation correction was performed in the PLIF in both groups throughout the final follow-up period.

Table 3. Comparison of radiological assessment between two groups

	Ragiological assessment						
	Group I			Group II			
Parameters	Slip angle (°)	Disc height (%)	Lumbar lordosis (°)	Slip angle	Disc height	Lumbar lordosis	p value
Preoperative	12.5°±0.5°	20%±9%	10.2°±3°	11.9°±1.1°	19%±10%	9%°±2%	0.33
1 month	10.1°±0.5°	40%±19%	19°±8°	9.9°±0.5°	37%±17%	18%°±7%	0.06
3 month	8.0°±0.7°	53%±20%	30°±15°	7.8°±1.1°	55%±21%	31%°±14%	0.05
6 month	6.0°±1.2°	55%±22%	43°±19°	6.1°±0.7°	58%±23%	37%°±16%	0.05
1 year	4.0°±1.1°	60%±27%	51°±22°	3.5°±0.1°	59%±23%	47%°±21%	0.005
F/U	2.1°±2.1°	60%±28%	60°±29°	2.5°±0.9°	60%±25%	58%°±21%	0.005

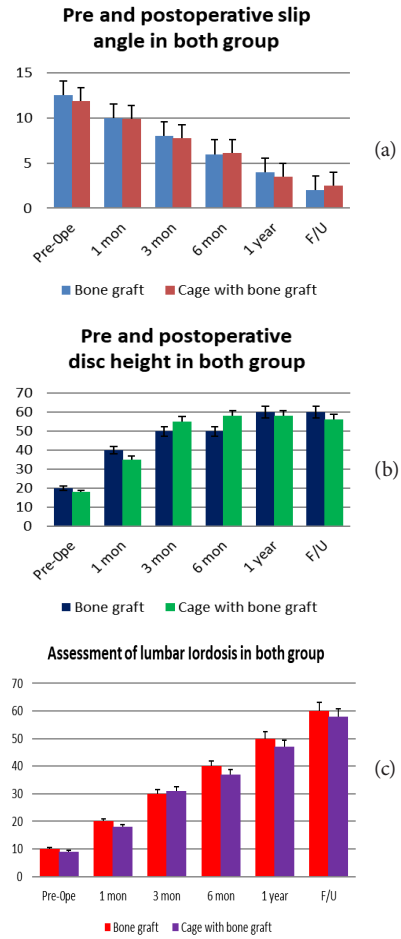


Figure 2. Radiological assessment to observe pre and postoperative in both groups, (a) Slip angle bar graph shows significantly reduced slip angle after surgery, (b) Disc height bar graph shows significantly increase disc height in both group, (c) Lumbar lordosis bar graph shows significantly increase lumbar lordosis in postoperative in both group

In our study, maximum flexion and extension was observed in the bone graft group (3.7±1.1) and cage bone graft group (3.3±0.2). At postoperatively in both groups there was (4.4±2.9) mm and (4.2±2.3) mm and show significantly limited translation motion, p<0.005 in (Table 4), (Figure 3a, b). The fusion rates in both the groups were 93% and 87%, respectively (p>0.005) (Table 1).

Following are the findings for each parameter in group I (bone graft) and group II (cage with bone graft): In Table 1; the hospital stay was (30.5±5.5, 29.9±1.3) days and the surgical time was (185.2±9.1, 185.3±8.8) minutes. The following complications developed: Three serious problems occurred in all groups: one patient experienced persistent leg pain; one had a deep wound infection and one had a vein thrombosis (Figure 4, 5).

Table 4. Comparison of flexion and extension slip and translation between two groups

	Flexion and extension slip (n=15) mean±SD		Flexion and extension translation (n=15) mean±SD		
Parameters	Group-I	Group-II	Group-I	Group-II	p value
Preoperative	3.0±0.2	3.3±0.1	3.7±1.1	3.3±0.2	0.03
1 month	3.5±0.5	2.5±0.6	3.5±2.1	3.3±1.1	0.03
3 month	3.3±0.4	2.9±1.1	3.9±2.1	2.9±1.1	0.05
6 month	3.5±0.7	3.8±1.5	3.9±3.1	3.4±2.8	0.05
1 year	3.7±1.2	3.7±2.1	2.5±3.3	2.2±2.9	0.05
F/U	3.9±1.1	3.5±1.9	4.4±2.9	4.2±2.3	0.05

SD: Standard deviation

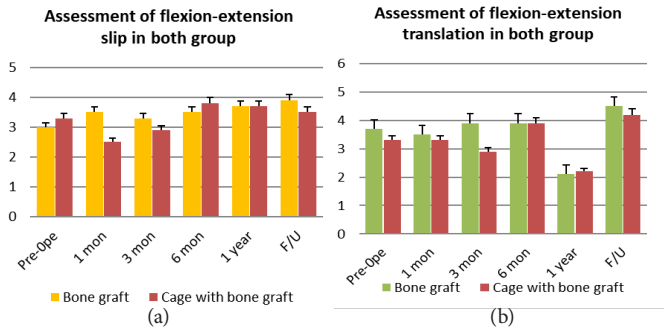


Figure 3. Flexion and extension of slip angle and translation assessment in both groups, (a) Bar graph shows similar flexion and extension slip angle in both group, (b) Bar graph shows similar flexion and extension translation in both group

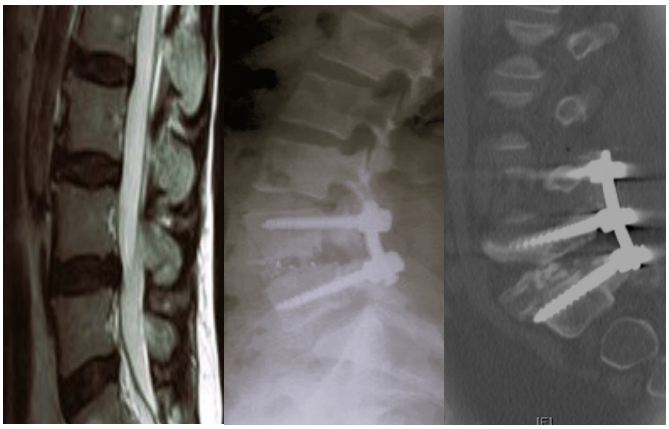
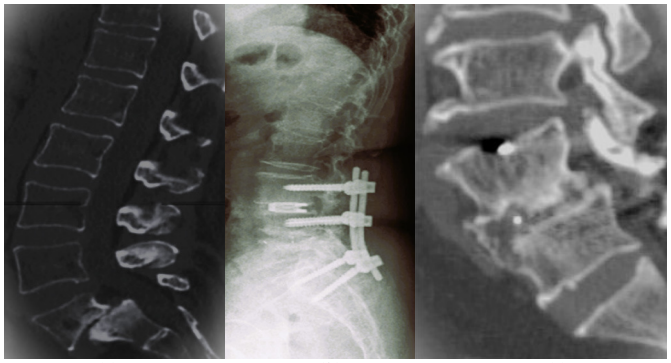


Figure 4. Case 1: Bone graft alone PLIF surgery, (a) Preoperative MRI, (b) 45 years old age patients the intervertebral discs, spinal cord and nerve roots may all be evaluated with MRI well. Following PLIF with a bone graft, MRI can be used to assess the following conditions: the condition of the disc space between the vertebra and any adjustments to disc height. The existence of soft tissue problems, infection or inflammation the way the brain structures and spine are oriented, (b, c) CT scans image, of the spine's bones and are especially helpful for evaluating bone structures. Following PLIF with a bone graft can demonstrate whether the bone graft and surrounding vertebra have effectively fused

PLIF: Posterior lumbar interbody fusion, MRI: Magnetic resonance imaging, CT: Computer tomography



(a) (b) (c)

Figure 5. Case 2: Cage with bone graft PLIF surgery, (a) Preoperative CI image, (b) 50-year-old patient arrived at the hospital complaining of a low back pain. There was no recent trauma in the past, (b, c) CT scan image show vertebra fused

PLIF: Posterior lumbar interbody fusion, CT: Computer tomography

DISCUSSION

Restoration of lordosis, preservation of intervertebral disc height, anterior column support and indirect foraminal decompression are among the potential benefits of PLIF.[16] In patients with grade III lumbar spondylolisthesis, they suggested screw systems and cages because improved stability may permit successful fusion around the cages.[17,18]

In both groups (bone graft and cage with bone graft), PLIF offered improved fusion rates, preservation of reduction and anterior column support.[19,20] In our study, PLIF in both groups demonstrated a noticeably shorter surgery time. In groups I and II, it was possible to obtain better sagittal balance and the JOA scores for leg function and back discomfort were better three months after surgery than before. There was a statistically significant improvement in the postoperative status compared to the preoperative status within the each group.[21,22]

The evaluation of JOA ratings prior to and following PLIF with two distinct graft alternatives (bone graft and cage with bone graft) can shed light on the effect of the procedure on leg function and low back pain. Patients were assessed using the JOA score prior to the PLIF operation and low back pain, leg pain, sensory impairments, motor deficits and bladder function were just a few of the different aspects that the JOA score evaluates. A baseline for the patient's condition was established during this preoperative evaluation which also acted as a benchmark for gauging recovery from surgery. Usually during a follow-up session following PLIF surgery, the JOA score is reevaluated. The patient's condition following surgery is reflected in the postoperative JOA score which assesses changes in leg function and low back discomfort. The difference between preoperative and postoperative JOA scores is a numerical indicator of a patient's condition improvement or decline. Following PLIF, higher postoperative JOA ratings, especially in the low back pain and leg function components, showed improvement in these areas. The nature of the spinal condition, the surgical technique, the patient's age and general health and the success of the graft integration can all have an impact on the postoperative JOA scores for patients who underwent PLIF with a bone graft and those who underwent PLIF with a cage and bone graft.[23] We were agreed from the previous study. It should also be noted that recovery can differ from person to person. The low back pain improvement rates of the bone graft group and the cage with bone graft group showed similar effects.

In our study, the slip angle, disc height space and lumbar lordosis were measured on radiological images of all patients and compared between the bone graft and bone graft groups.[24] In patients undergoing PLIF surgery or with diseases such as spondylolisthesis, the slip angle, disc height and lumbar lordosis are crucial spinal characteristics. They used a slip threshold of 5 mm and a slip angle of 8°-10° to divide the patients into two groups: stable and unstable. Instability was assessed by measuring the degree of slide (>54 mm) and slip angle (>10°) in the subjects. The slippage angle between neighboring vertebra was measured using the slip angle. The degree of spinal displacement is commonly indicated by an increase in slip angle in diseases such as spondylolisthesis.[25,26] PLIF lowers the slip angle and stabilizes the spine. The procedure involves fusing the afflicted vertebra together in order to stop further slippage and enhance spinal alignment. There was a significant reduction in the slip angle postoperatively between the groups treated with PLIF and those treated preoperatively. We were agreed from the previous study.

The distance between neighboring vertebral discs is referred to as disc height. The compression and degeneration of intervertebral discs can result in disorders such as spondylolisthesis which can result in a reduction in disc height. To restore disc height during a PLIF procedure, the degenerative disc is frequently removed and a bone graft or cage is inserted.[27] This promotes fusion and aids in maintaining an appropriate distance between vertebra. There was a significant increase in disc height after surgery in both groups different postoperative and preoperative outcomes.

The typical inward curve of the lumbar spine is called the lordosis. Spondylolisthesis is a condition that can change curvature. Restoring and maintaining lumbar lordosis after PLIF surgery since it is necessary for optimal spinal alignment and function. PLIF surgical methods and equipment are used to maintain or replicate this curvature in bone grafts as well as cages with bone grafts. PLIF surgery aims to enhance the patient's quality of life, reduce pain and restore spinal stability both postoperatively and at follow-up.[28,29] Depending on the needs and unique condition of each patient it is optimal to reduce or eliminate the slip angle after surgery, restore the disc height and maintain or improve lumbar lordosis. After postoperative comparison with preoperative data, the fusion rate was 93% in the first group and 83% in the second group which was achieved in 14 patients in group I and 13 patients in group II using posterior elements removed from the decompression procedure as bone grafts and a cage with bone graft as implemented.[29] We were agreed from the previous study.

When bone grafts and cages with bone grafts are used, a combination of MRI and CT scans may be utilized to offer a thorough assessment of post-PLIF outcomes.[30] Although CT scans offer comprehensive information on bone fusion, hardware placement and radiographic fusion.[31] MRI is useful for evaluating soft tissues and associated problems. Examination of these imaging results is often undertaken during follow-up meetings with surgeons or healthcare professionals.[32] To evaluate the success of the procedure and whether further care or monitoring is required, they will analyze the photographs and consider the clinical symptoms. Working closely with your medical team is crucial to ensuring that the right imaging tests are performed and the

outcomes are carefully assessed in order to monitor recovery and the effectiveness of PLIF treatment with a cage and bone transplant.

CONCLUSION

These findings suggest that successful clinical and radiological results can be obtained with PLIF surgery using either a cage with bone or a bone graft alone. The surgeon's inclination, the particular state of the patient and the resources at hand may influence which of the two approaches is used. The results showed no statistically significant difference between the two groups in terms of clinical and radiological outcomes (bone graft and cage with bone graft). This indicates that neither strategy showed a clear edge over the others in the criteria under study and both were equally successful in yielding favorable outcomes.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of Ethical Committee of the Hitit University Faculty of Medicine Researches Ethics Committee (Date: 05.08.2021, Decision No: 2021-19).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution and analysis of the paper and that they have approved the final version.

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